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TECHNICAL EVALUATION REPORT ON THE GUIDANCE AND CONTROL PANEL T--ETC(U)
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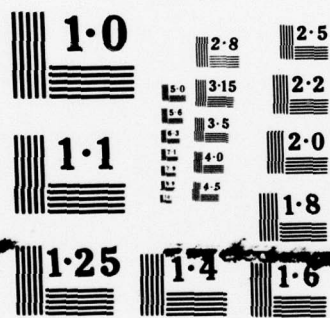
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AGARD ADVISORY REPORT No. 115

Technical Evaluation Report
on the

24th Guidance and Control Panel
Technical Meeting:

Symposium on
Applications of Advances in Navigation
to Guidance and Control

DISTRIBUTION STATEMENT

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NORTH ATLANTIC TREATY ORGANIZATION
ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT
(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

AGARD Advisory Report No. 115
TECHNICAL EVALUATION REPORT
on the
24th GUIDANCE AND CONTROL PANEL TECHNICAL MEETING (24th),
Symposium on
APPLICATIONS OF ADVANCES IN NAVIGATION
TO GUIDANCE AND CONTROL

The GCP Symposium was held in Stuttgart, Germany, 10-13 May, 1977. The program as presented at the symposium is appended to this report. The complete compilation of papers has been published as Conference Proceedings CP-220.

The technical evaluation for each session has been done mainly by the session chairmen and edited by the program chairman. The evaluation includes most of the comments and recommendations which were received from the participants in the symposium.

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- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field;
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Published June 1978

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ISBN 92-835-1281-2



*Set and printed by Technical Editing and Reproduction Ltd
Harford House, 7-9 Charlotte St, London, W1P 1HD*

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**TECHNICAL EVALUATION REPORT on the
24th GUIDANCE AND CONTROL PANEL TECHNICAL MEETING:
Symposium on
APPLICATIONS OF ADVANCES IN NAVIGATION
TO GUIDANCE AND CONTROL**

1. THEME AND OBJECTIVES

Positioning and navigation systems provide essential information to guide and control any aircraft, weapon or reconnaissance system on a required trajectory to accomplish the prescribed mission phases. Within the last decade there have been significant advances in positioning and navigation techniques making possible great improvements in guidance and control systems and hence in the resulting mission performance and capabilities. It was the objective of the symposium to promote constructive ideas and discussions on the application of these recent advances in navigation to guidance and control.

The users and the engineers are fully aware of the new advances in positioning and navigation destined for application to guidance and control. On the other hand, the problem of cost-effectively applying these techniques seems not to have been conclusively solved until now. The cost of aircraft and systems, in real terms, has steadily risen and NATO countries are compelled to have fewer aircraft. Cost is the reason for the very real and continuous struggle between complexity (with increased capability) and simplicity (with reduced capability, but larger numbers). There is a tendency to add a new piece of equipment to aircraft systems — another box — without removing anything, thus resulting in further increasing complexity and cost. It was the purpose of the symposium to consider advanced positioning and navigation systems related to guidance and control which perform functions that can replace other pieces of equipment. It was intended to stimulate thinking for the avoidance of proliferation, looking for more elegant, simpler and less costly systems which give the same or even better performance.

The aims which led to the decision to hold this meeting were:

- (1) to review the increased technical capabilities of those guidance and control systems which would benefit from advances in positioning and navigation;
- (2) to discuss whether these increased capabilities derived from the advances in positioning and navigation will lead to more cost-effective solutions to guidance and control systems.

2. SYMPOSIA PROGRAM AND TECHNICAL EVALUATION

2.0 Keynote Session

The Keynote Session was intended to introduce the attending engineers and scientists to the users' point of view. The keynote speakers were requested to cover scenario, environment, military necessities and requirements rather than to advocate any particular system or solution.

Air Commodore Grocott (RAF, UK) gave an *Operational Overview on where Advances in Navigational Techniques should Lead to Significant Improvements in Mission Effectiveness*. Covering the changing scenarios from 1930, the keynote speaker concluded that there is a necessity for airforces to be capable of operating in more than one role, in both the land/air and the maritime/air environments and at both low and medium level. This requires multipurpose navigation and attack systems.

The areas in the land/air environments where advances in navigational techniques should lead to significant improvements in effectiveness are: close air support, interdiction, and counter-air operations. The target location problem is likely to be improved in close air support by adoption of a common reference system between ground and air forces, of equal accuracy under clear conditions and in a dense electronic and hostile air defence environment. Systems should enable an aircraft to locate SAM systems, to launch weapons against these systems from outside their lethal envelopes, to stand off and launch anti-armour weapons, and to launch weapons against targets spotted outside the cone associated with first-pass attacks. The navigational improvements which are required in the counter-air field mission are linked entirely to the target phase, for which positions should be known to a high order of accuracy.

In maritime operations (namely, anti-ship, anti-submarine warfare and air defence) the developments that would appear most significant are those connected with the provision of a common reference navigation and command and

control system for all craft, and navigation and guidance developments associated with the tracking and attack phase of anti-submarine and anti-ship operations.

Developments which appear to offer significant improvements in mission effectiveness have to be carefully considered when weighing the promised improvements in operational effectiveness against the projected cost.

As second keynote speaker, Major General E.A. Coy, Director of Space, Office of the Deputy Chief of Staff, Research and Development, HQ USAF, gave an address on *Challenges in Research and Development*.

2.1 Session I – Improvements in Inertial Navigation Systems (INS) and their Applications

The scope of the session, which aimed at covering both the improvements in inertial navigation systems and their resulting applications, was undoubtedly very ambitious. This, obviously, was recognised by the Program Committee, which selected an adequate sample of papers covering a wide range of topics, the emphasis being mainly on applications.

Despite the short time available (five papers were presented) the objective of the session was satisfactorily reached; the only shortfall was, perhaps, the paper on low-cost, strap-down inertial system which was rather component-orientated.

The session was probably beneficial both to specialists directly involved in the development of inertial navigation and those who expected a general review of the overall improvements of INS and current potential application. The applications discussed or suggested in the session were spread over an extremely large domain (sea-bed survey, accurate blind weapon delivery, improved landing capability for civil aircraft, . . .) reflecting a true picture of the present INS potential.

It is regrettable that some authors read their papers, or presented them in too modest a manner. This may be the reason why the most interesting paper, that on inertial smoothing and extrapolation of ILS beams, did not trigger a lively discussion.

2.2 Session II – Improvements in Radar and Radio Navigation Aids and their Applications

Radar and Radio Navigation Systems are the second main group of the most important navigation aids. This session was considered as being complementary to the previous one. Unfortunately, the scope and the goal of this session were too broad for the subject to be adequately covered. For future symposia, it is recommended to have an expert to present a survey paper and that this be followed by papers dealing with selected highlights, rather than having highly specialized papers that do not give a complete picture.

The first three papers dealt with special navigation systems. The first reported on multiple angulation as a radar support system, based on angle measurements by conventional DF-systems and appropriate calculation within an associated microprocessor. The second paper considered application of ground-based angle measurement technology for en-route navigation. This technique integrates DME and angle measurement and constitutes a reliable and economic solution for navigation systems. The third paper dealt with a more theoretical method on TACAN one-way ranging by synchronizing the airborne system once before take-off.

The first paper on applications in this session led into the field of RPV ranging, trilateration and communication. In this case, spread-spectrum communication by pseudo-random modulation and synchronized demodulation provides a high degree of ECM resistance. The discussion on this theme was restricted due to the security classification of this subject. A considerable amount of discussion was stimulated by the last paper which compared present MLS accuracy requirements and flight-path deviation caused by MLS-independent effects, such as air turbulence and wind shear.

2.3 Session III – Specific Functions and System Concept

This session was intended to explore the subject of relating navigation systems to mission objectives. Most of the comments indicated that the objective was met to a medium degree.

The withdrawal of two papers for security reasons caused some imbalance in the treatment of mission applications. For example, missions involving helicopters were not covered. In addition, the papers presented emphasized specific applications, but without adequate presentation of the trade-off considerations leading to the final approach. For example, trade-off analyses comparing inertial and GPS would have been valuable.

All papers read in this session were of high quality and relevant to the subject matter. Future sessions on applications can be improved if a trade-off analysis is included to provide rationale for a selected design approach. In addition, the discussion of cost, reliability, vulnerability, as well as accuracy, is desirable. Classification of papers is suggested if it is necessary to reveal key data. To support the assumptions of values used in analyses, test data should be included. All papers in this session suffered from one or other of these deficiencies.

In spite of the problems with classified papers and the last-minute shuffling of presenters in this session, all of the papers were well-focussed on mission application. Also, the papers were of high technical quality and were professionally presented. Judging from the number of comments received after the session (13), plus the lively question-and-answer period during the session, the papers were well received.

2.4 Session IV – New Major Systems

This session was intended to familiarize engineers, scientists, and users, with the coming generation of multifunction systems with the capability of navigation, position reporting, and distribution of tactical information.

There was an excellent paper read by Col. B.W. Parkinson, USAF, on the NAVSTAR Global Positioning System. This was to some extent a repetition of the presentation made by Col. Parkinson many times before but it brought the audience up-to-date on the progress and status of the program. There was also a survey of the many applications. In this presentation, and also in an earlier paper ("Global Positioning System Navigation Application to Tactical Missiles") it came out that, for many military applications, especially in the vicinity of heavy jamming, the most powerful combination looks like being GPS combined with an inertial navigator. It was clear that the NAVSTAR GPS is being successfully developed, will be installed, and will have many applications.

The second paper was on the Position Location Reporting System (PLRS). This system is being developed jointly for the US Army and US Marine Corps and is designed to meet battlefield tactical location requirements. It operates in the UHF band over a 30 megahertz bandwidth (420–45 MHz) and uses Time Division Multiple Access (TDMA). The concept is of one master unit controlling 370 user units. The position accuracy required and achieved on trials is 10–30 meters. The system will use various methods, including frequency hopping for ECCM. It will be cryptographically secure, and there will also be extra security provided by TDMA. It will be usable also in helicopters.

The Joint Tactical Information Distribution System (JTIDS) and its applications were presented by Col. Brentnall, USAF. JTIDS, a joint development program by the US military services, is a radio Communication Navigation Identification (CNI) system providing tactical elements for a wide range of services. Receiver-transmitter terminals are being developed for a range of applications including airborne, ground-based, and seaborne communications, command and control (C³); CNI for tactical vehicles; data links for unmanned systems; and C³ relay through unmanned stations and platforms. The system provides jam-resistant digital data exchange, precision relative ranging between units, and positive identification and position correlation of users. The system design is based on a pseudo-noise-modulated, frequency-hopped signal characteristic, which provides for jam-resistant, secure data communications on a rigidly-structured time-division multiple-access basis. The relative ranging data is used in several ways, including precision relative grid community navigation, multi-lateral survey of beacons, weapons control, TACAN functions, and community distribution of geographic fix data. The various relative navigation techniques are described and their relation to other navigation devices discussed.

Finally, there was a paper on a Short-Range Navigation Aid and Tactical Positioning System for Army Helicopters, presented by Otto H. Schoenberger of the Avionics Laboratory, US Army, and Robert Follen of Honeywell Inc. This is a very interesting system which began as an anti-collision device for Army helicopters. It uses a precise radar altimeter and an interrogate/respond technique to obtain proximity warning, within a relative altitude of 300 ft and selectable ranges up to 5,000 ft. The system has worked very well for some years as Collision Warning, and is now being extended to include an azimuth indication capability. This session should have been classified, maybe Secret. Again, this caused the late withdrawal of some papers. All papers presented were of high quality and met most of the expectations. The likely question to what extent New Major Systems with multi-function capability will replace conventional ones was not really answered. Insufficient information was given to enable a comparison in sufficient depth to be made with respect to cost, reliability, vulnerability and accuracy. The question as to whether these New Major Systems are the solution for increased performance with less complexity and cost is still open. It is suggested that additional discussion should be stimulated in future symposia.

2.5 Session V – System Improvements and Concepts

This session gave an overview of how advances in navigation could lead to Guidance and Control System improvements and to new concepts in this field.

The first two papers dealt with the improved capability of hybrid navigation, including updating by ground tracking. These papers, as with several others presented during the symposium, showed the good performance which can be obtained by mixing, through Kalman filter, several measures which have complementary qualities. The results in the paper from K. Hurrass, DFVLR, could be especially useful for the design of low-cost navigation systems with the highest degree of performance.

In the third paper the development of the integrated all-weather navigation system for the MRCA was reported. The paper was interesting since practical aspects of a hybrid navigation system were described. The system reported represented the state-of-the-art and did not indicate specific improvements.

The last paper covered navigation, guidance and control for high-performance military aircraft. Apart from being too much of an advertisement, it was a good and relevant paper on display requirements utilizing the capabilities of the navigation system without unacceptable pilot workload.

3. CONCLUSIONS, RECOMMENDATIONS, GENERAL COMMENTS

The following remarks are a cross-section of all the individual evaluations received from observers, speakers and session chairmen.

On the whole, the quality and relevance of papers were considered to be good, but if the classification had been raised, more real information might have been provided. The non-classification of the meeting was also reflected in the quality of the discussions. The presentation of performance data of most interest was not allowed and, as a result, some papers of major interest ended up only as general overviews. The papers generally supported the theme and nearly all comments indicated that the symposium was very useful as a basis for familiarization with current trends and advances in navigation and their applications to Guidance and Control. It is regretted that there were a lot of very theoretical papers. If no practical implementation of the theory can be foreseen, this type of paper seems to be of little interest for the audience.

Desirable changes, as indicated by several comments, are as follows. The highest permitted level of classification should be adopted for comparable future symposia. The lack of more practical solutions integrating the operational needs and technical possibilities should be covered. It seems to be desirable to extend discussion periods and to encourage, even more, all attendees and specially-qualified observers to discuss more fully the subject matter of papers, since lively discussions seems to be as valuable to the audience as the quality of the papers.

Most comments indicated that today there exists enough position-finding capability. The state-of-the-art of technology in inertial as well as in radio and radar systems provides for sufficient accuracy for nearly all mission profiles. It seems remarkable, however, that while concern has been voiced about the proliferation of navigation and guidance and control systems, new additional developments are being initiated (PLRS, JIIDS, GPS). It was suggested that perhaps the major challenge is to utilize what already exists in a more simple and less costly integrated system. The problem of the integration of navigation and position-finding equipment in a system cannot be regarded as conclusively solved. Operational needs seem not to have been sufficiently covered, if complexity, cost, reliability and vulnerability are considered, in addition to performance and accuracy. Integration in guidance and control systems includes integration of the pilot into the system, the mission, and the command structure in a simple way. New solutions are promised for the future by the multifunction systems presently under development, including position-finding, position-reporting, and the capability for the distribution of tactical and other data for a whole fleet of aircraft. Again, for these systems, the process of integration into the guidance and control system has not yet been solved. Current concepts do not satisfactorily indicate how much of other system parts will be substituted by these multifunction systems. Some comments indicated that proliferation could even increase. It was agreed that more information about these new emerging systems should be distributed and that the question of their integration should be treated. Their use mainly for improved weapon delivery seemed to stimulate interest.

The organization of the symposium, the location and overall logistics were good. The program was in danger of disruption because of the late withdrawal of papers. This led to some re-organisation at the last minute. To avoid a recurrence of this situation the security aspects of announced papers must be sorted out earlier and invitations should only be addressed to speakers who are well-known and reliable. It was regrettable that papers were distributed too late or even not at all. This made preparation impossible. The suggestion was made that those papers which are not distributed until the opening ceremonies of the meeting starts should be cancelled. Some speakers simply read out their written papers. This was contrary to the instructions to authors. Many visual aids were not readable.

ANNEX

**AGARD Guidance and Control Panel 24th Technical Meeting
SYMPOSIUM ON "APPLICATIONS OF ADVANCES IN NAVIGATION
TO GUIDANCE AND CONTROL" held at the Theodor-Heuss-Kaserne,
Stuttgart, Germany: 10-13 May 1967**

FINAL PROGRAM

OPENING CEREMONIES

Reference

WELCOME ADDRESS by General-Major Walitschek

KEYNOTE SESSION

AN OPERATIONAL OVER-VIEW ON WHERE ADVANCES IN NAVIGATIONAL TECHNIQUES
SHOULD LEAD TO SIGNIFICANT IMPROVEMENTS IN MISSION EFFECTIVENESS

by D.F.H.Grocott, RAF, Ministry of Defence, UK

K1

CHALLENGES IN RESEARCH AND DEVELOPMENT

by E.A.Coy, Headquarters, USAF

K2

SESSION I - IMPROVEMENTS IN INERTIAL NAVIGATION SYSTEMS AND THEIR APPLICATIONS

Chairman: Dr A.Benoit, Belgium

FUTURE APPLICATIONS OF LOW COST STRAPDOWN LASER INERTIAL
NAVIGATION SYSTEMS

by J.B.Matthews and D.R.Bates, Jr, Raytheon Co., USA

1

NEW TECHNIQUES FOR LOW COST STRAPDOWN INERTIAL SYSTEMS

by P.M.Brodie and C.R.Giardina, Singer Kearfott Division, USA

2

LISSAGE ET EXTRAPOLATION INERTIELS DE FAISCEAUX ILS - APPLICATION
A L'AIRBUS A 300B (In French and English)

par J.Irvoas, SNIAérospatiale, P.Lloret, SAGEM, D.Buisson, SNIAérospatiale
et X.Lagarde, SAGEM, France

3

RECENT ADVANCES IN HIGH RESOLUTION INERTIAL NAVIGATION

by K.R.Brown and R.A.R.Tait, Ferranti Ltd., UK

4

CALIBRATION OF AN INS BASED ON FLIGHT DATA

by B.Stieler and W.Lechner, DFVLR, Institut für Flugführung, Germany

5

SESSION II - IMPROVEMENTS IN RADAR AND RADIO NAVIGATION AIDS AND THEIR APPLICATIONS

Chairman: Professor P.Form, Germany

UHF DF TRIANGULATION SYSTEM FOR CONTROL AND GUIDANCE OF MILITARY
AIRCRAFT

by B.F.Ernst, Rohde and Schwarz, Germany

6

PRECISE ENROUTE NAVIGATION BASED ON GROUND-DERIVED TECHNIQUES

by G.Blaschke and G.Peuker, SEL, Germany

7

ONE-WAY RANGING WITH TACAN

by M.Bohm, SEL, Germany

8

AN ECM-RESISTANT COMMUNICATION AND RANGING SYSTEM FOR RPV

H.Sepp, Siemens AG, München, Germany

9

ACCURACY CONSIDERATIONS ON NEW MICROWAVE LANDING SYSTEMS (MLS)
FROM AN OPERATIONAL POINT OF VIEW

by A.Becker, DFVLR, Institut für Flugführung, Germany

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Chairman: R.W.Wedan, USA

- A MULTI-SENSOR IMPLEMENTATION FOR NAVIGATION, POSITION LOCATION, POSITION UPDATE, RECONNAISSANCE AND WEAPON DELIVERY – AN/ARN-101(V)**
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- SHORT RANGE NAVIGATION AID AND TACTICAL POSITIONING SYSTEM FOR ARMY HELICOPTERS**
by O.H.Schoenberger, US Army Electronics Command
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- A HYBRID GUIDANCE SYSTEM FOR ALL-WEATHER APPROACH AND LANDING**
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- DEVELOPMENT OF THE INTEGRATED ALL-WEATHER NAVIGATION SYSTEM FOR TORNADO (MRCA)**
by H.F.Schwegler, Messerschmitt-Bolkow-Blohm, Germany 22
- NAVIGATION, GUIDANCE AND CONTROL FOR HIGH PERFORMANCE MILITARY AIRCRAFT**
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- AREA NAVIGATION SYSTEMS AND PROCEDURES***
by D.W.Richardson and J.S.Tyler, Systems Control, Inc. (Vt) USA 24

CLOSING CEREMONIES

* Not presented at the meeting; however included in the published Conference Proceedings

REPORT DOCUMENTATION PAGE			
1. Recipient's Reference	2. Originator's Reference AGARD-AR-115	3. Further Reference ISBN 92-835-1281-2	4. Security Classification of Document UNCLASSIFIED
5. Originator	Advisory Group for Aerospace Research and Development North Atlantic Treaty Organization 7 rue Ancelle, 92200 Neuilly sur Seine, France		
6. Title	TECHNICAL EVALUATION REPORT on the 24th GUIDANCE AND CONTROL PANEL TECHNICAL MEETING: Symposium on APPLICATIONS OF ADVANCES IN NAVIGATION TO GUIDANCE AND CONTROL		
7. Presented at			
8. Author(s)			9. Date June 1978
10. Author's Address			11. Pages 12
12. Distribution Statement	This document is distributed in accordance with AGARD policies and regulations, which are outlined on the Outside Back Covers of all AGARD publications.		
13. Keywords/Descriptors	Inertial navigation Radio navigation All weather navigation		
14. Abstract	<p>The GCP Symposium was held in Stuttgart, Germany, 10-13 May, 1977. The program as presented at the symposium is appended to this report. The complete compilation of papers has been published as Conference Proceedings CP-220.</p> <p>The technical evaluation for each session has been done mainly by the session chairmen and edited by the program chairman. The evaluation includes most of the comments and recommendations which were received from the participants in the symposium.</p>		

<p>AGARD Advisory Report No.115 Advisory Group for Aerospace Research and Development, NATO</p> <p>TECHNICAL EVALUATION REPORT on the 24th GUIDANCE AND CONTROL PANEL TECHNICAL MEETING: Symposium on APPLICATIONS OF ADVANCES IN NAVIGATION TO GUIDANCE AND CONTROL</p> <p>Published June 1978 12 pages</p> <p>The GCP Symposium was held in Stuttgart, Germany, 10-13 May, 1977. The program as presented at the symposium is appended to this report. The complete compilation of papers has been published as Conference Proceedings CP-220.</p> <p>P.T.O.</p>	<p>AGARD-AR-115</p> <p>Inertial navigation Radio navigation All weather navigation</p>	<p>AGARD Advisory Report No.115 Advisory Group for Aerospace Research and Development, NATO</p> <p>TECHNICAL EVALUATION REPORT on the 24th GUIDANCE AND CONTROL PANEL TECHNICAL MEETING: Symposium on APPLICATIONS OF ADVANCES IN NAVIGATION TO GUIDANCE AND CONTROL</p> <p>Published June 1978 12 pages</p> <p>The GCP Symposium was held in Stuttgart, Germany, 10-13 May, 1977. The program as presented at the symposium is appended to this report. The complete compilation of papers has been published as Conference Proceedings CP-220.</p> <p>P.T.O.</p>	<p>AGARD-AR-115</p> <p>Inertial navigation Radio navigation All weather navigation</p>
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